A Study on Usage of Agricultural Engineering Equipment for Various Crops and Yields in South Tamilnadu

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ABSTRACT

Agriculture is one of the unique fields to contribute a major part of Indian economic growth. Engineering machinery plays a vital role in the farming culture in India. The focal point of this research is fully concentrated with Agri engineering equipment and crop yield based on the repository taken from various sources like the internet, agri departments, government agencies, etc. The research study shows statistical proof of crop production and machinery used for farming in the south zone of India. In particular, southern components of Tamilnadu state are taken as a sample for this research. It has been identified paddy is widely cropped in the majority of the districts like Madurai, Theni, Dindigul, etc. Machine learning techniques are now being used in the Agri sectors for the prediction of crop yields and as a result visualization of data done in this research for the various crops and machinery used. It is to conclude that Agri machinery is nowadays used for farming for better yield of the crops.

KEYWORDS

Agriculture, Clustering, Machine Learning, Paddy, Prediction

INTRODUCTION

Today's rapidly growing different technologies including agriculture is act as a major part of our India. Farming innovates the massive growth in the economy of India. In recent years, the government of India has launched a digital agriculture mission for projects based on new technologies such as artificial intelligence, blockchain, remote sensing, and GIS technology, the use of drones and robots, and so on. Waleed et al. (2021) enforced the multi-class supervised machine learning techniques for classifying the agriculture farm machinery. IoT and machine learning algorithms have been widely used for automation and analysis (Gomez-Chabla et al., 2019; Jha et al., 2019). Kumar et al. (2015) developed Crop Selection Method for maximizing crop net production rate throughout the season.

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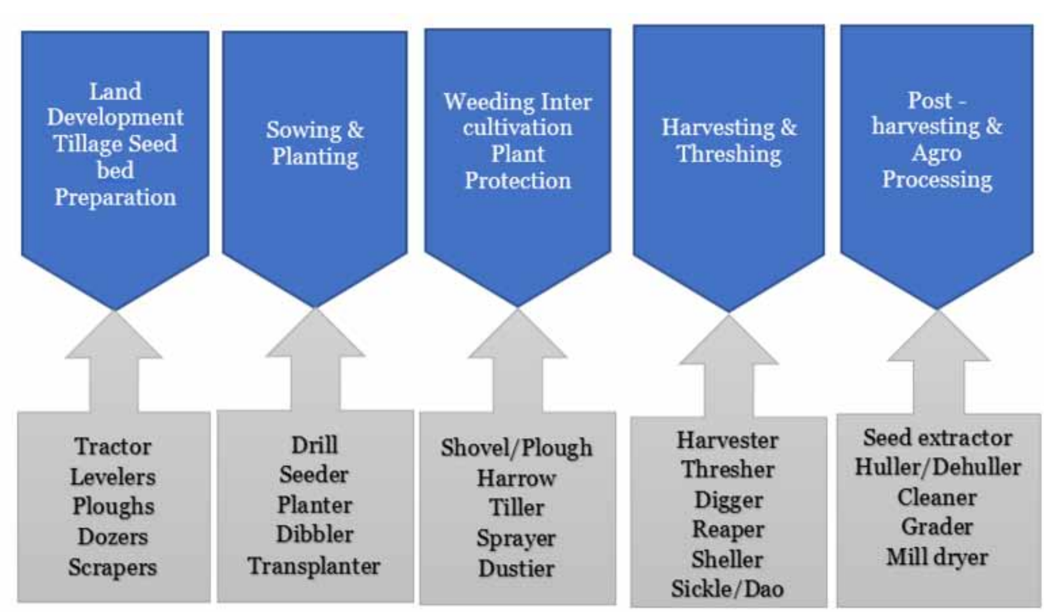
Design a crop field control system based on node sensors, with data management via smartphone and a web application (Muangprathub et al., 2019). In Agriculture, crop production depends on the season, biological, and economic cause. So, predicting agricultural yield is a challenging and desirable task for every state of India (Sujatha, 2016). Crop Advisor is a user-friendly web page that forecasts the impact of climate variables on crop output (Veenadhari et al., 2014). Son (2020) presented the Random Forest and SVM models for large-scale rice yield projections were found to be successful. Suganya et al. (2020) proposed a method using supervised learning techniques for the recommendation of Crops to be farmed based on soil, weather, and previous year's production data to the farmers. Droughts with lower geographical extents have become more common as a result of recent climate changes (Mohammed et al., 2018). Conservation agriculture has long been viewed as a cost-effective and environmentally friendly method of increasing crop yield (Xiao et al., 2020). Shukla (2018) in her research compares the performance of various machine learning methods for large-scale crop classification. It is found from the literature review that the crops like Wheat, paddy, red tensils, etc were used in most of the places in the southern districts of Tamilnadu. Machine learning approaches, for example, can improve decision-making by providing better risk and variability management to achieve maximum yields and improve economics (Antonopoulos et al., 2020).

Farmers face challenges during the cultivation of specific crops by unpredictable climatic changes and a drastic reduction in water resources. In India, New technologies had been implemented in the agricultural sector and it is being spread out throughout our nation. This new technology could help the farmers to accurately find the climate forecast, low level of water usage, maximize the yield, and get more profits. The most important techniques of agriculture equipment have led to efficient tilling, harvesting, and a reduction in physical work. Modern farm machinery has increased in size, speed, and productivity, allowing for more efficient cultivation of greater land. Seed, irrigation, and fertilizers have all improved significantly, allowing farmers to enhance yields.

There are many different sizes and shapes of agricultural tools, and they all help a farm or garden be more productive and look better. Figure 1 shows the various agricultural implements used in different stages of farming starting from land development and Seedbed preparation with tractor attachments such

Figure 1. Types of agriculture equipment used in farming



as levelers, plough, and rotavators, then planting and sowing seeds with a drill, seeder, transplanter, etc. Further weeding, inter-cultivation process with the use of sprayers for fertilizers, tillers, and shovels. In the final stage of harvesting the crop major equipment such as harvester, thresher, and reapers were used. Post harvesting takes place for the next-level phases of farming the land and it's a cyclic process. The additional level of agri-machinery to be implements in south zone to be listed below:

This research is divided into several sections: South Tamil Nadu is home to the most widely cultivated crop, paddy, and a literature review on the various machine learning techniques used in agriculture, the prediction of crop yield, and the cultivation of paddy. Then Research Methodology focuses on the clustering method to map areas of the farm with the crop yield in regions of south Tamilnadu. The framework has been designed for the research followed by results and discussions. This study's primary objective is to predict the Agri machinery and types of crops in the region of south Tamil Nadu by employing clustering methods, and it was discovered that paddy is the principal crop with the highest production in all the districts. The estimation of crop production is one of the most important aspects of agriculture, as it is essential for agriculture planning involving proper crop selection, providing farmers with accurate profit projections for the crop they intend to sow, and determining the import and export decisions of farmers. The unsupervised machine learning algorithm technique has been implemented in this study. Hierarchical clustering identifies patterns in a data set consisting of various crops and production values collected from 32 main cities in south Tamil Nadu over the previous ten years and provides the leading crop production prediction in the south area. This proposed work will assist farmers in cultivating the most profitable crop on their farmland, hence increasing their profitability.

LITERATURE REVIEW

Meshram et al. (2021), presented that Machine learning is an adopted technology of farming to reduce the loss and provide a maximum level of recommendation to improve insights into the crop.

Table 1. List of sample agricultural machinery used for farming in Tamilnadu

BACKHOE DOZER	Backhoes are utilised for excavating soil, constructing building foundations, digging trenches for pipe and cable laying, handling garbage, widening rural roads, removing bushes and trees, etc. Dozer is used for agricultural land levelling, constructing farm bunds and farm terracing, constructing roads and clearing sites, filling trenches in dam projects, after laying cable or wire, etc.
ANIMAL DRAWN DISC HARROW	It is used for secondary tillage operation
MOULDBOARD PLOUGH	Ploughs are used for primary tillage operations. It cuts trash and buries it completely. It is also used for turning and mixing these materials in the soil.
DISC PLOUGH	Disc plough is used for primary tillage and is especially useful in hard and dry, trashy, stony or stumpy land conditions and in soil where scouring is a major problem
SPRING TYNE CULTIVATOR	Cultivators are used for seedbed preparation both in dry and wet soils. It is also used for interculture purpose by adjusting the tynes in wider row crops. It is also used for puddling purposes.
RIGID TYNE CULTIVATOR	It is useful for subsoil cultivation and also eliminates the use of ploughs even for hard soils. The duck foot shovel version is ideal for surface cultivation i.e. shallow cultivation and interculture.
DUCKFOOT CUL TIVATOR	Used for primary tillage operation, destruction of weeds, and retention of soil moisture.
ROTAVATOR	It is suitable for preparing seedbeds in a single pass both in dry and wetland conditions. It is also suitable for incorporating straw and green manure in the field.
LAND LEVELLER	It is suitable for land preparation operations such as scraping, grading, leveling, and back filling. It is also used for irrigation, terrace work, and general cleaning of the field.

Machine learning techniques to extract the new generalized decision tool in crop management (Dimitriadis, 2008). Wei et al. (2020) evaluated by Random Forest regression to be accurate and suitable to predict carrot yield to satellite analysis. Cloud data of smart watering equipment was also gathered and analyzed based on ML techniques to compare the four different techniques like Naive Bayes, Decision Tree, Bayesian Network, Random Forest. That comparison shows the best result in the Random Forest algorithm (Vasu et al., 2019). The Grey Prediction system presents a technique that gives good accuracy in price forecasting in the market for agriculture production. To forecast the price of agricultural products in the system, the Prediction method is used. The demand rating for the crop approach is given by Zong & Zhu (2012). In Bangladesh, a website has been developed for the rural people and farmers to assist in agriculture through voice messages in their native language (Gurstein, 2013).

Lots of Tractor Implements are currently used by Indian Farmers especially in Tamilnadu state for Land Preparation, Sowing &Transplanting, Harvesting, and Post-Harvest Material Handling.

Land development is the costliest preparation in farming. It involves jungle clearance, soil opening with deep tillage equipment, moving soil from high to low spots, making farm roads, field bunding and leveling, etc. Rotavator or Gyrovator is a light series rotary tiller specially designed for high performance in light and medium soils in both dry and wet soil conditions. Its lightweight and robust design make it a complete solution for the progressive farmers tilling needs.

9 tyne and 5 tyne cultivators are used for Hard terrain or rocky, and it provides a quality farming experience in less time, everywhere. Rotavator is highly efficient in its range, equipped with multi-speed gears & great rotor speed ratio. It can simultaneously cut, mix & level the farm - saving valuable time. A wide range of tractor implements and self-propelled farm machinery for operations from land preparation to post-harvesting, to suit a wide range of crops and farm sizes. These products are designed to deliver ultimate operational ease and excellence to the farmer.

These operations require the use of self-propelled and heavy equipment such as crawler tractors with heavy-duty ploughs and dozers, high horsepower tractors with dozing arid hoeing attachment, scrapers, ditchers, chisel ploughs, subsoilers, terracers, levelers etc. The tillage operations, defined as mechanical manipulation of soil, are performed to achieve the desired seedbed to provide an optimum environment for seed germination and plant growth. Seedbed preparation for sowing/planting of different crops is done through primary and secondary tillage operations. A microcontroller-based embedded system for automatic slip-draft control was designed, developed, and tested for a 2WD tractor. The system synchronously measures and controls the wheel slip and implement′s draft closer to the set ranges under varying field conditions (Gupta et al., 2019). The development of a comprehensive ANN model now makes it possible to answer fundamental questions in the domain of the effect of ploughing depth and forward speed on energy indices of tractor-implement that were previously intractable (Shafaei et al., 2019). The practicability of lateral stiffness measurement is shown by experiments on a three-point linkage plough and cultivator (Reece et al., 1966). Pods of oilseed rape (Brassica napus) stronger than those in current cultivars are needed to reduce the considerable loss of seed caused when the fragile, mature pods open before or during harvest (Bruce et al., 2001). A prototype of a liquid recycling and air circulation tunnel sprayer was tested in a peach orchard during two different periods, and performance compared with that of an axial fan air-blast sprayer (Ade and Pezzi, 2001). A study was undertaken for the design and development of a power tiller-operated single row potato planter with a bucket elevator type metering mechanism. The potato planter consisted of a seed hopper, bucket elevator type metering mechanism, seed pipe, furrow opener, plate type ridge former, depth control wheels, ground drive wheel, and chain drive for power transmission to the bucket elevator mechanism (Pal and Chattopadhyay, 2020). Biometric properties of chili (Pusa Jwala) and tomato (Abhilash) plug seedlings of 30-, 45- and 60-day old relevant to the design of vegetable transplanter were investigated (Khadatkar et al., 2020). Pranay Sarkar (2021) developed a three-wheeled planter consisting of a suitable hopper for onion sets, conveying system, robotic arm, seed tube, furrow opener and closer, and necessary electronics circuits (Pranay Sarkar, 2021).

The suitability of a vibrating dual bent-share cultivator was studied (Esehaghbeygi et al., 2020). The adaptation of some existing technologies such as sugarcane-type harvester, jute/reed-type harvesters, and forage harvesters for kenaf harvesting has not been successful (Falana et al. 2020). A machine that can sow seeds of paddy, wheat, black gram, mung bean, lentil, mustard, and radish in rows was designed and developed at the Department of Farm Power and Machinery, Bangladesh Agricultural University (Ali, 2019). The broadcasting method for jute seed planting is time-consuming, create constraints in weeding, thinning, fertilizer application, and harvesting (Ekka et al., 2019)

Paul et al. (2015) described in their research the technique of predicting crop production using a data mining approach for a recommendation of crop-based on market prices and demand. Zhang (2004) proposed Crop yield estimation using data mining techniques. Suma (2021) proposed to the green field, drone activation via IoT confronts crop status and stages, irrigation, and plant leaf diseases. It is found in the literature that there exist methods for finding crop damages and some improvement is still required for the betterment of finding damaged crops (Morota et al., 2018). Tiwari (2021) presented effective techniques for solving various agricultural problems of varying complexities that can be carved out through the intelligent use of data mining and its tools such as cluster analysis.

RESEARCH METHODOLOGY

The methodology adopted for this study included heuristic evaluation, a usability survey questionnaire, a cognitive walkthrough experiment, and think-aloud and co-participant testing. (Tang et al., 2006). It also discusses the framework used for this research and includes details of the geographical area, datasets, and data visualization of Agri implements and crops concerning the geographical area of south Tamilnadu.

A FRAMEWORK FOR CROP VARIETY PREDICTION

This research framework consists of data collected from various resources like the Agricultural department, a survey questionnaire, government agencies, and web resources. This data source was particularly collected from the year 2020 guide of crop production agriculture. Figure 2 shows the framework for crop variety prediction. In this proposed framework, the experiments are carried out using well-known classification algorithms in python programming. Python with Colab is a software platform developed by Google that provides an integrated environment for machine learning, predictive analytics, and data analytics. It is one of the world's most popular and most used open-source machine learning solutions. Data are pre-processed and cleaning takes place by removing white spaces, special characters with the predefined functions in Python. The Machine learning technique Hierarchical clustering is applied to predict the crop range and various Agri implements in this framework.

GEOGRAPHICAL LOCATIONS OF THE AREA USED FOR THIS RESEARCH

This research was carried out at almost 33 districts in south Tamil Nadu which is shown in figure 3. In all the places various crops were cultivated with the use of Agri machinery implements to farming lands. In recent years, the Tamil Nadu government has led the way in a variety of policies and technologies aimed at driving an innovation-driven change in agriculture. The cultivable land in Tamil Nadu, which includes seeded area, present fallow lands, and other fallow lands, accounted for 58 percent of the total geographical area, while the net sown area was 36 percent of the entire geographical area.

The major crops cultivated in the southern districts of Tamilnadu are shown in Figure 3 and they are categorized into four different types (i) Food Crops (ii) Cash crops (iii) Plantation crops and (iv) Horticulture crops. The crop variety based on the category is listed in Table 1.

Figure 2. A framework for crop variety prediction

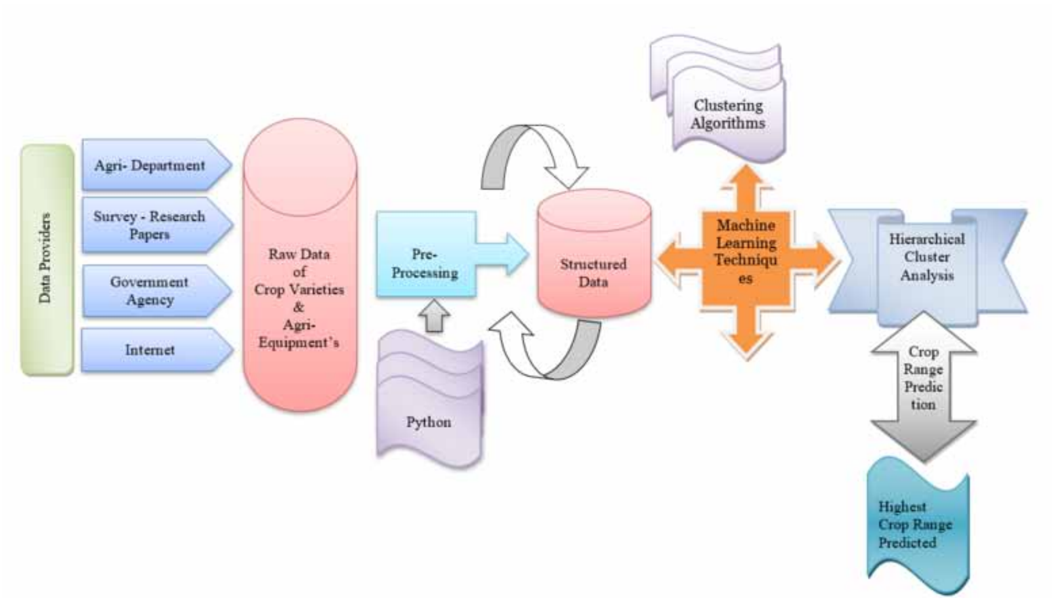
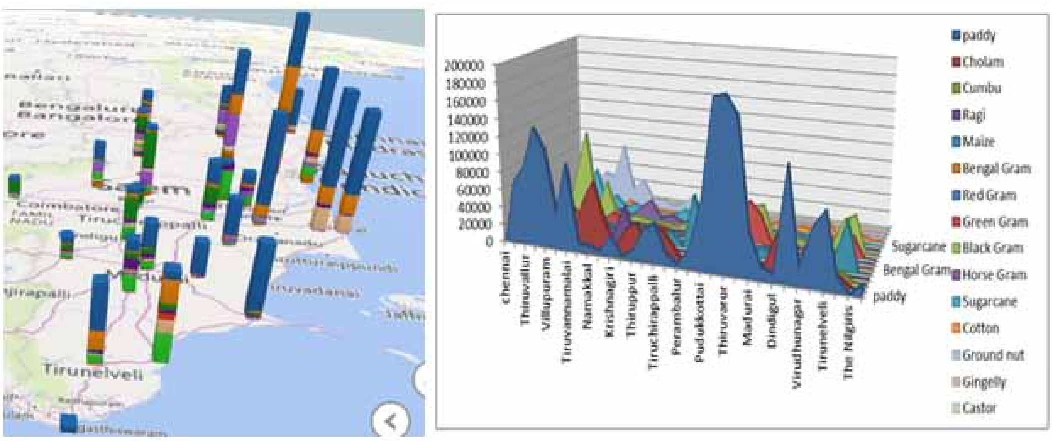


Figure 3. Geographical locations of the area used for this research



Paddy is the major crop found top in the variety which is shown in figure 4 with high production of 160000 metric tonnes during 2020-2021 and millets and pulses placed in the middle and castor is the low-produced crop in the southern parts of Tamilnadu. Rice, maize, jowar (cholam), bajra (cumbu), Red gram, Green gram, ragi, and pulses are anticipated to be farmed important food crops of south regions.

USAGE OF AGRI-EQUIPMENT'S IN SOUTH TAMILNADU

Agriculture is practised while operating within the context of the surrounding ecology. Because the environment encompasses all of the tangible things in our immediate vicinity, we must accord it a

Table 1. Crop's categories in the south zone

S.No.	Category	Crops Variety
1	Food Crops	Paddy, Cholam, Cumbu, Maize, Pulses, and Millets
2	Cash Crops	Sugarcane, Tobacco, Cotton, Jute, and Oilseeds
3	Plantation Crops	Coffee, Coconut, Tea, and Rubber
4	Horticulture Crops	Fruits and Vegetables

high level of significance. The development and proper operation of cutting-edge machinery, as well as the most recent implementations of digital farming solutions, are two examples of the many ways in which agricultural engineering has the potential to significantly improve the long-term viability of agriculture on a global scale. These forward-thinking solutions may be used to the effective cultivation of crops as well as to the processing of biological resources in order to meet the demand of consumers as well as a broad variety of businesses for food, feed, fibres, bioenergy, and bio-based goods. Agricultural engineering plays an important part in the development of engineering-based methodologies and decision support tools for waste process and treatment to reduce greenhouse gas emission, to reduce and correctly apply pesticides and fertilisers, and for the management and protection of soil, water, and environmental resources. Agricultural engineering also plays a role in the development of new agricultural technologies. The engineering concepts behind sustainable agriculture include the innovative design of structures, facilities, monitoring systems, and equipment for agricultural output, as well as ergonomics and the organisation of work. Agricultural mechanisation, automation and robotics, high-efficiency irrigation systems, farm energy systems, post-harvest handling and processing, wastewater management, and the accompanying sustainable bioenvironment are all closely tied to these. Such investigations into agricultural engineering are necessary in the 21st century, in especially when seen from the perspective of the link between agricultural water, energy, and food safety. The levels of Agri-equipment's in various farm operations such as seedbed preparation, sowing/Weeding, planting/transplanting plant protection, intercultural, and harvesting and threshing for large amounts of grain crops (rice, wheat, maize, sorghum, and so on) millets, pulses, oilseeds, cotton, and so on Production systems for sugarcane shown in Table 2.

Dataset

The sample dataset used is called the crop variety production dataset in this research. This crop dataset is an authentic dataset taken from https://tnau.ac.in. There are 15 crops in the dataset which are – Paddy, Cholam, Cumbu, Ragi, Maize, Bengal Gram, Red Gram, Green Gram, Black Gram, Horse Gram, Sugar cane, Cotton, Groundnut, Gingelly, Castor is measure the tonnes per hectare of farming land in south tamilnadu districts. Each file contains details about crop production levels in different districts of south Tamil Nadu from Crop Production Guide 2020. District wise crop dataset is shown in Table 3.

RESULT & DISCUSSION

Machine learning is the dependency of Artificial Intelligence which is used to build algorithms that exposition self-learning properties. ML is an innovative technique that benefits farming activities, reduces the losses of Agri sectors, and highly recommend deep knowledge about crop production. In this research, a Hierarchical clustering approach is used to analyze the variety of crops. The parameters taken as an input for Hierarchical clustering are district, different variety of leading crops, production range and it is experimented using python programming. Table 4 shows how different research efforts have used diverse machine learning methods of various crops prediction.

Table 2. Usage of agri-equipment's in South Tamilnadu

Agri-equipment for field Operations in (%)					
Leading Crop	**Seed Bed Preparation**	**Sowing/Planting/ Transplanting**	**Weeding&Plant Protection**	**Harvesting & Threshing**	**Post-Threshing**
Rice	70	20	30	60	60
Wheat	70	60	50	70	50
Maize	60	40	30	30	40
Millets	50	30	15	10	20
Pulses	50	40	20	25	30
Oilseed	50	40	20	25	30
Cotton	50	30	25	0	0
Sugarcane	55	10	20	10	0

Table 3. District wise crop dataset samples (in Tonnage)

District	Paddy	Cholam	Cumbu	Ragi	Maize	Bengal Gram	Red Gram	Green Gram	Black Gram	Horse Gram	Sugar-Cane	Cotton	Ground Nut	Gingelly	Castor
1	246	0	0	0	0	0	0	2	0	0	0	0	0	6	0
2	70375	27	9	214	3	0	11	599	3951	0	1876	0	13976	1673	0
3	88873	1	526	263	4	0	155	7535	1169	12	5461	0	5369	1989	0
4	133360	19	3619	83	21667	0	34	10112	50836	1	17138	5907	9680	2637	71
5	110521	258	17804	2833	21014	0	197	890	100587	87	48020	5104	36584	8838	20
6	40637	4913	1916	5521	3074	14	10226	2394	4503	8765	5628	3205	32623	600	200
7	97047	22	2441	3182	1211	0	1569	1159	43240	6865	18126	586	73488	1806	0
8	9753	50605	832	5144	35226	16	1849	11940	4887	5770	5600	9418	19988	1185	635
9	7635	76245	168	486	9157	309	661	6413	2413	1193	10813	2431	32108	464	1327
10	3889	32134	632	11507	6244	1767	8626	2354	6109	12187	4893	9230	9585	413	175
11	22961	4829	756	42800	3238	2	7753	1591	4052	23252	555	1681	11285	981	1124
12	1599	27123	173	15	4013	1358	260	764	639	1972	440	713	4650	219	11
13	10407	36391	41	1	21105	2134	104	2077	2654	7283	2966	1152	7850	471	55
14	35561	44	175	5626	14541	0	1474	468	1254	1437	12214	988	18843	5314	455
15	44261	36097	314	9	15628	3	1577	402	6525	1022	1784	8863	6583	1107	308

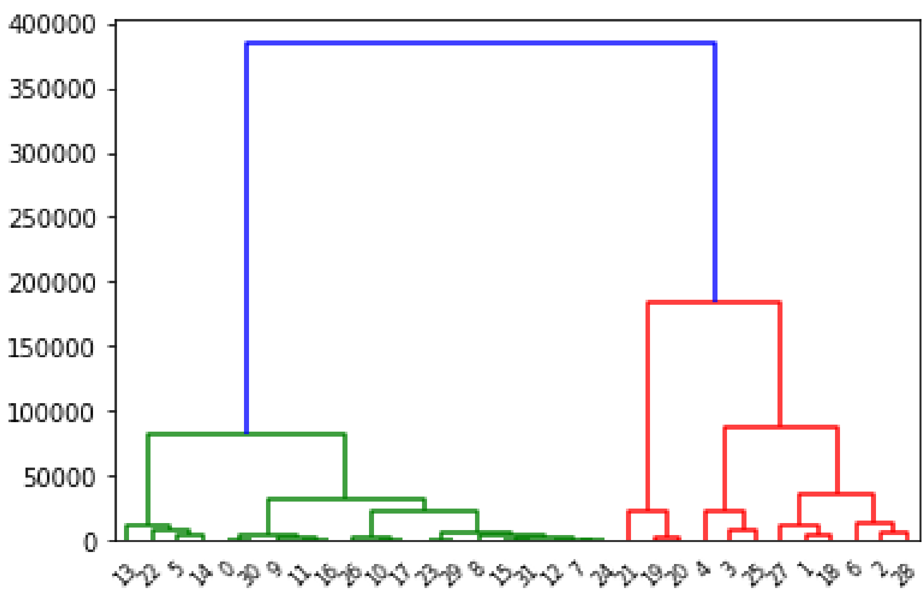
From table 4, It is found that machine learning algorithms are widely used nowadays in agriculture domain. There are many chances of predicting crop yields and clustering based on different parameters such a s rainfall, nutrients, soil conditions etc. From the literature and the past researches, it is strongly recommended that Hierarchical clustering is well suited for crop prediction. Figure 4 represents the Hierarchical clustering of Crop Production ranges of the 32 districts in South Regions divided into two clusters. X-axis: Districts; y-axis: Production Ranges from Crop.

In this figure 4 describe the Dendrograms are frequently used to examine hierarchical clusters before deciding on the number of clusters that should be used for the dataset. Dendrograms are used in this research for visualization of crop yield in the district which is a tree-like chart that shows the sequences of cluster merges or splits, to determine the optimal number of clusters for hierarchical clustering to determine the predictive evaluation of highest crop group in south tamilnadu. The number of clusters is six since the horizontal line crosses the blue line three way of clustered separated in the dendrogram points.

Table 4. Comparison of machine learning algorithms used for crop prediction

S.No.	Crop	Method	Reference
1	Rice	Random forests (RF) and support vector machines (SVM)	[43]
2	Rice	XGBoost Algorithm	[33]
3	Wheat	Extreme learning machine & support vector regression	[12]
4	Sugarcane	Support Vector Machine Regression	[21]
5	Fruits & Vegetables	Multiple linear regression	[29]
6	Ragi	K-means & Decision Tree Regression	[44]
7	Rice, Maize, Ragi & Bajra	Random forest classification	[15]
8	Maize	LASSO, RF, XGBoost & LSTM	[41]
9	Sugarcane	Random Forest Algorithm	[9]
10	Rice	Density-Based Clustering	[54]
11	Tomato	K-Means Clustering	[24]
12	Barley, Canola & Spring Wheat	Hierarchical Clustering	[17]

Figure 4. Hierarchical clustering of crop production ranges of the 32 districts in south regions divided into two clusters. X-axis: Districts; y-axis: Production ranges from crop



The Hierarchical clustering method is one of the unsupervised learning strategies that clusters the data set into one or more clusters. The data with similar features are sorted into one cluster, while the other data are grouped into another cluster, so that the data in one cluster has a limited degree of variation. In this proposed work, the Hierarchical clustering method was applied to crop production data from the agriculture web portal in an effort to generate feasibility information for each district in south Tamil Nadu. Figure 5 shows the Cluster formation result of the Hierarchical cluster algorithm, which tells us that 15 crops samples fall under the low category, under medium, and under high. Thus,

Figure 5. Visualization of crops

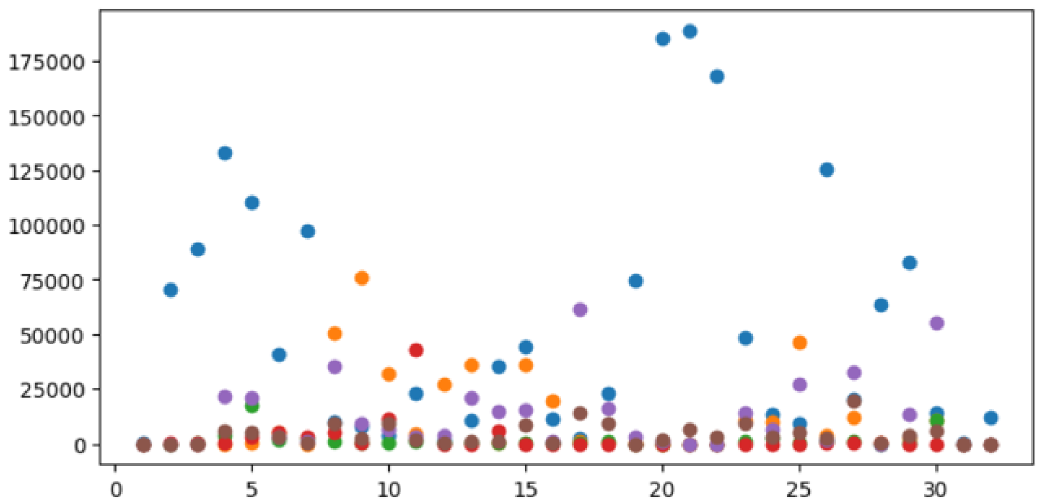
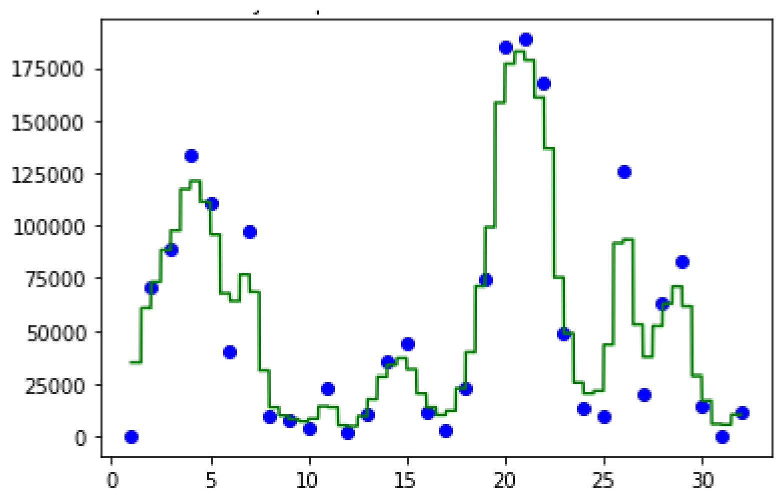


Figure 6. Leading crop of rice range visualization



by experimenting with the Hierarchical cluster algorithm on the given datasets, it can say that crops production implement Agri-equipment based to give high category crops to evalution.

In such cases, accurate yield prediction is extremely beneficial to global users. Accurate forecasts allow for timely import and export decisions. Farmers can use yield prediction to make more informed management and financial decisions. This research study concludes with a district-by-district analysis of crop varieties production to finalize the result of the leading crop of the south region predicted by this research is the leading ranges of Paddy crop (figure 6). This study used a large amount of crop production data set that was implemented with a hierarchical clustering technique that was well suited for this work.

CONCLUSION

In recent years' agriculture sectors have also followed digital resources. The new technologies act as the backbone of agriculture sectors in current days. Machine learning is an important part of solving the difficulties in the agriculture sector. This study predicts the crop ratio of almost all kinds of crops that are planted in south Tamilnadu. Advanced clustering techniques like Hierarchical clustering and pre-process with python libraries are used in this study to predict the crop yield and use the concept of Agri-equipment involvement in the development of crop production to give a better prediction. Using a data set comprised of different crops and production values gathered from 32 important districts in south Tamil Nadu over the past ten years, hierarchical clustering has been able to identify patterns and produce the most accurate prediction of agricultural output in the region. The proposed work will help farmers maximise their earnings by allowing them to grow the most lucrative crop possible on their land. This study investigates the advanced unsupervised approaches such as clustering algorithms and the notion of hierarchical clustering to enhance the algorithms and provide a more accurate forecast of crops and its ranges in south Tamilnadu. The research's limitations include a thorough examination of the most recent machine learning applications in agriculture to solve issues in the pre-harvest, harvest, and post-harvest phases. The emphasis is on how machine learning can be used in agriculture to improve productivity and efficiency while requiring less labour from humans. The further research assesses the most important characteristics for enhancing the paddy cultivation ranges in an efficient manner using machine learning approaches. Future work may aim to create more efficient framework models using other machine learning classification techniques such as SVM, PCA, NB, RF, etc.

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